Utility Earthquake Mitigation

Considerations
Requirements
Actions

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National Earthquake Conference
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Araneda, Rudnick, Mocarquer and Miquel
IEEE Powercon Oct 2010

Impacts on Electricity Supply from the 2010 Chilean Earthquake

Araneda, Rudnick, Mocarquer and Miquel
IEEE Powercon Oct 2010
Chilean Codes include strict seismic standards (IEEE 693) for all electricity infrastructure

February 27, 2010 an 8.8 Richter scale earthquake hit the central part of Chile

Electricity Supply Impacts Generation

- Immediate Loss of 4,522 MW
- 693 MW of Generation from 16 plants required extended time for repair (6.1% of total installed capacity)
Electricity Supply Impacts

<table>
<thead>
<tr>
<th>TRANSMISSION DAMAGES</th>
<th>Number</th>
<th>Damaged</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substations</td>
<td>46</td>
<td>12</td>
<td>26%</td>
</tr>
<tr>
<td>Transmission lines (km.)</td>
<td>7280</td>
<td>1.6</td>
<td>0.02%</td>
</tr>
</tbody>
</table>

Electricity Supply Impacts

Distribution

[Graph showing the distribution of clients affected by supply disruptions, with a red line indicating the number of clients without supply and a blue bar graph showing the percentage of clients without supply for different periods.]
Electricity Supply Impacts

Operations

- Communication systems severely impacted
- Ten year old SCADA system determined inadequate for the event
- Subsequent global blackout one week later caused by protection control cable damaged in the original quake

New Madrid Power Plant
New Madrid Plant
Seismic Considerations

- Unit 1 was designed to conform to the 1967 Uniform Building Code for a Zone 3 seismic area
- Unit 2 was designed to conform to the 1970 Uniform Building Code for a Zone 3 seismic area
- Static design earthquake forces were determined in accordance with the Uniform Building Code for Zone 3

Turbine foundation contains 280 Piles
Earthquake Probabilities for New Madrid Seismic Zone

<table>
<thead>
<tr>
<th>Richter Scale</th>
<th>30 year Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.3</td>
<td>90%</td>
</tr>
<tr>
<td>7.1</td>
<td>67%</td>
</tr>
<tr>
<td>7.6</td>
<td>25%</td>
</tr>
<tr>
<td>8.3</td>
<td>3%</td>
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</tbody>
</table>

Turbine Trip
Turbine /Gen Damage Structural Damage Total Loss

Major Pipelines Traversing New Madrid Seismic Zone

- Natural Gas Pipeline
- Ground shaking intensity on the Modified Mercalli Intensity (MMI) scale
  - VII
  - VIII
  - IX
  - X
  - XI

Associated Electric Cooperative, Inc.
Estimated AECI Long-Term Generation Loss Following Magnitude 7.0 Quake

<table>
<thead>
<tr>
<th>Generation Loss</th>
<th>MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Load Generation Loss</td>
<td>1200</td>
</tr>
<tr>
<td>New Madrid</td>
<td></td>
</tr>
<tr>
<td>Intermediate Generation Loss</td>
<td>1081</td>
</tr>
<tr>
<td>St Francis and Dell</td>
<td></td>
</tr>
<tr>
<td>Peaking Generation Loss</td>
<td>107</td>
</tr>
<tr>
<td>Essex</td>
<td></td>
</tr>
<tr>
<td>Total Generation Loss</td>
<td>2281</td>
</tr>
</tbody>
</table>

Seismic Design Considerations for Electric Facilities

- IEEE 693 – Seismic Qualification Standard (69kV and above)
- ASCE Structure Design Guide (MOP 113)
- ASCE/SEI 7–10 for substation buildings
Seismic Design Requirements for Electric Facilities

- Nuclear Regulatory Commission Approval
- Rural Utilities Service—Bulletin 1724E–300
- PUC—None
- Federal—None

WHAT PREPARATIONS HAVE BEEN MADE?
National Level Exercise (NLE) 2011

AECI Facilities Involved with 2011 NLE

- New Madrid Plant
- St. Francis Plant
- Dell Plant
- Essex Plant
- Headquarters
Dell Power Plant Fuel Oil, Foundation Upgrade

Equipment Foundation Bolts
Dell Fire System—Retrofit Needed

Currently, required seismic gaps are non-existent

Future Plant Design
CONCLUSIONS

- Known impacts from prior events can guide preventive measures prioritization for Seismic Designs
- Design Requirements for Electric Facilities are essential to minimize expected earthquake impacts
- Critical Electric Grid facilities may in the future be subject to FERC earthquake measures (Currently do not exist)
- State Public Utility Commission (PUC) requirements may be implemented in the future